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RELATIONS BETWEEN BASELINE CONTINGENCIES AND EQUIVALENCE PROBE PERFORMANCES

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Following the emergence of two three-member equivalence classes (A1B1C1 and A2B2C2), 5 college students were exposed to one or more changes in the reinforcement contingencies controlling baseline conditional discriminations. AC relations were either reversed (i.e., C2 was reinforced and C1 punished when A1 was the sample; C1 was reinforced and C2 punished when A2 was the sample) or arranged randomly (i.e., C2 and C1 were reinforced and punished equally often in the presence of A1 and A2). In a third condition, the original AB and AC relations were reversed. Results showed that although baseline conditional discrimination performances were under the control of reinforcement contingencies, and performances on symmetry trials varied with baseline responding for 3 of 4 subjects when contingencies were reversed, performances on transitivity probes remained consistent with the initial equivalence class. These inconsistencies between probe and baseline performances were striking because conditional discriminations are thought to be the determinants of equivalence class performance. Similarly, the contrast between performances on symmetry and transitivity probes was of theoretical interest because equivalence classes are defined by congruent patterns of responding on probe trials.

Key words: stimulus equivalence, stimulus classes, conditional discrimination, Wisconsin General Test Apparatus, object displacement, college students

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Studies of stimulus class formation typically begin with conditional discrimination training. For example, a subject may be taught that choosing Comparison Stimulus B1 will be reinforced when Sample Stimulus A1 is presented (A1B1), but that choosing Comparison B2 will be reinforced when A2 is the sample (A2B2). With a different set of comparison stimuli, reinforcers follow choice C1 given sample A1 (A1C1) and C2 given A2 (A2C2). When human subjects have been exposed to such training contingencies, novel patterns of conditional responding, derivable from the trained relations but not explicitly reinforced, have emerged. Typically, these novel patterns exhibit the properties of stimulus reflexivity (e.g., choosing A1 in the presence of A1), symmetry (e.g., given the training described above, choosing A1 in the presence of B1), and transitivity (e.g., given the training described above, choosing C1 in the presence of B1)—the defining features of equivalence classes (Sidman & Tailby, 1982). The similarity between equivalence classes formed via conditional discrimination training in the laboratory and the function of symbols in natural languages has been noted frequently (e.g., Devany, Hayes, & Nelson, 1986; Sidman, 1986; Wulfert & Hayes, 1988), and stimulus equivalence methodologies have generated considerable attention as a viable experimental approach to the behavioral analysis of symbolic processes.

To date, investigations of stimulus equivalence have tended to focus on variables influencing class acquisition and expansion (e.g., Bush, Sidman, & de Rose, 1989; Dube, McIlvane, Mackay, & Stoddard, 1987; Saunders, Wachter, & Spradlin, 1988; Sidman, Kirk, & Willson-Morris, 1985; Wulfert & Hayes, 1988). Few experiments, however, have analyzed variables that influence maintenance, loss, or modification of established equivalence relations. Such analysis might further exploration of similarities between the properties of equivalence classes and natural language processes with respect to accommodating change given new learning experiences.

The present research examined procedures

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that might be effective in modifying established equivalence classes. Baseline conditional discriminations were manipulated following the emergence of two three-member equivalence classes (i.e., A1B1C1 and A2B2C2). In one condition, AC reinforcement contingencies were reversed, making possible new equivalence classes (i.e., A1B1C2 and A2B2C1). In a second condition, the contingencies acting on AC relations were arranged so that no given pattern of responding was reinforced consistently. The C stimuli were not explicitly related to either stimulus class under these conditions. In the third condition, both of the original conditional discriminations were reversed, again making possible new equivalence class memberships (i.e., A1B2C2 and A2B1C1). The goal was to determine how performances on probes for stimulus equivalence would be affected by exposure to altered conditional discrimination contingencies.

METHOD

Subjects

Five UNC–Wilmington undergraduate students, 4 female and 1 male, served as subjects. Four subjects began their participation to fulfill introductory psychology course requirements but were paid for participation beyond the first two sessions. A 5th subject (Subject DA) was paid for participating throughout the study.

Apparatus

Subject and experimenter sat at a table on opposite sides of a modified Wisconsin General Test Apparatus (WGTA). The WGTA was a wooden box (17 cm by 24 cm by 60 cm) open on both ends allowing both the experimenter and the subject visual and physical access to half of the apparatus. A sliding guillotine door bisected the apparatus, and a wooden partition (65 cm high) prevented visual contact between the experimenter and the subject.

Experimental stimuli were six three-dimensional wooden objects of various shapes and colors (A1 = purple oval; B1 = green triangle; C1 = natural color curved shape; A2 = yellow square; B2 = pink circle; C2 = natural color complex shape). The objects were approximately 2 cm by 2 cm by 1 cm and were mounted on black cardboard squares (5 cm by 5 cm). These stimuli were presented manually by the experimenter, who raised the guillotine door and slid a Plexiglas stimulus tray (25 cm in length) forward toward the subject. Three stimuli were presented simultaneously on each trial; a sample stimulus was located in the center of the tray, and two comparison stimuli were located on either side of the sample. Each stimulus object covered a concave well (3 cm in diameter) in which tokens could be placed. The subject responded by displacing a comparison stimulus and removing the token underneath if one was present. Tokens were deposited in cups beside the apparatus. The experimenter recorded all responses and prepared each trial.

Procedure

General procedure. The beginning of a trial was signaled when the experimenter raised the guillotine door of the WGTA and presented the stimulus tray to the subject. Preliminary instructions specified that the subject was to pick up one of the two side objects. On some trials this response revealed tokens that contributed to the subject's earnings. White tokens were defined as worth $0.01, and black tokens subtracted $0.01. Tokens were deposited in cups labeled "White" and "Black" and were accumulated throughout the session. (See Appendix for complete instructions.)

Replacing the stimulus object resulted in retraction of the stimulus tray, closure of the guillotine door, and initiation of a 15-s intertrial interval. Maximum presentation time for the stimulus array was designated as 8 s. If no response was made within this interval, the stimulus tray was retracted and the intertrial interval begun. (In no case did a subject fail to make a response within the allotted time.)

Trials were organized in blocks of 16. When one block was completed the next block began without interruption. As many trial blocks were completed as possible during 50-min sessions. Sessions were conducted 4 or 5 days per week, once or twice daily, with a minimum of 15 min between sessions. Subjects were paid a base rate of $3.00 per session, plus an extra $1.00 bonus per session when all contracted hours were completed. Additional earnings were accrued contingent on performance. Payments were made in cash at the end of the last session on Friday of each week.

Experimental history. All 5 subjects had completed two sessions of conditional discrimination training and equivalence class testing prior to their participation in the present experiment. Training and testing procedures were very similar to those used in the present experiment, with two exceptions. An unrelated set of three-dimensional abstract stimulus objects was used, and there were no financial contingencies for session performance. Four subjects participated to fulfill introductory psychology requirements and received no financial compensation for their involvement. Subject DA was paid a total of $3.00 upon her completion of the two sessions. In lieu of monetary backup for tokens, subjects were instructed that their job was to earn as many points as possible, that each white token added one point, and that each black token subtracted one point. Otherwise, instructions were identical to those in the Appendix.

Baseline conditional discrimination training. Subjects were taught two conditional discriminations (A1B1, A2B2, A1C1, and A2C2). Initial trial blocks consisted of a mixed baseline of four trial types (i.e., A1:B1B2, A2:B1B2, A1:C1C2, A2:C1C2). In a given trial block, each trial type was presented four times in a quasi-random sequence, with the restrictions that no one sample (A1 or A2) appear on more than three trials in succession and that no comparison stimulus (B1, B2, C1, or C2) appear in the same location for more than two trials in succession. Both samples appeared equally often, and comparisons appeared equally often in the two side positions. Displacing the comparison stimulus designated as correct for a given trial revealed a white token, and displacing the stimulus designated as incorrect revealed a black token.

Subjects who failed to make 14 correct responses within a block for five trial blocks were exposed to a sequence of reduced training baselines. For example, the first reduction involved a baseline of A1:B1B2 and A2:B1B2 trials. Failure to meet criterion after two trial blocks of exposure to a reduced baseline resulted in further baseline reduction (for example, A1:B1B2 trials alone) until criterion was achieved. Meeting criterion at any level resulted in addition of the previous baseline until criterion performance was maintained with all four trial types mixed.

Reinforcement rate was then reduced. On four trials of each block, one trial per trial type, token wells were not baited. When performance met criterion on two consecutive trial blocks, reinforcement rate was further reduced to 50% (i.e., two trials per trial type per trial block were unbaited). The baseline training phase was considered complete when criterion performance was maintained on two consecutive trial blocks with eight unbaited trials.

Stimulus class probes. Table 1 shows the composition of trial blocks once baselines were mastered (original conditions). After baseline training, every trial block (hereafter referred to as probe-trial blocks) consisted of four probe trials interspersed among 12 baseline conditional discrimination trials (six AB and six AC trials) in a quasi-random order. Two probe trials never occurred in succession. For a given trial block, probe trials tested for either stimulus reflexivity, symmetry, or transitivity. For every three trial blocks, one block that probed for each relation (i.e., reflexivity, symmetry, transitivity) was presented, but the order within each group of three blocks varied quasi-randomly. No two trial blocks that probed for the same relation occurred successively.

On reflexivity probe trials, comparison choices included either A1 and A2, B1 and B2, or C1 and C2, one of which was physically identical to the sample. Four of the six reflexivity relations were tested in each reflexivity trial block; all six were tested twice across every three reflexivity trial blocks. For trial blocks that tested symmetry or transitivity, B1, B2, C1, and C2 each appeared as the sample on one probe trial. On symmetry probe trials, comparisons were A1 and A2. On transivity probe trials, C1 and C2 were comparisons when the sample was B1 or B2, and B1 and B2 were comparisons when the sample was C1 or C2.

Overall reinforcement rate for a probe-trial block was 50%. Token wells were never baited on probe trials, and four baseline trials (one of each trial type) were also unbaited. These conditions were in effect for a minimum of four sessions and until stability criteria were met for all probe and baseline trial types. Stability criteria were met when the difference between the percentage of correct trials for the most recent three trial blocks of a type (i.e., reflexivity, symmetry, or transitivity) and the immediately preceding three trial blocks of the same type was no greater than 10% of the grand mean (the mean for all six trial blocks).

Table 1

Composition of trial blocks.

	Baseline trials			
	Original conditions	AC random	AC reversal	Complete reversal
Baited trials	A1:B1B2-2	A1:B1B2-2	A1:B1B2-2	A1:B1B2-2
	A2:B1B2-2	A2:B1B2-2	A2:B1B2-2	A2:B1B2-2
	A1:C1C2-2	A1:C1C2-1	A1:C1C2-2	A1:C1C2-2
	A2:C1C2-2	A1:C1C2-1	A2:C1C2-2	A2:C1C2-2
		A2:C1C2-1		
		A2:C1C2-1		
Unbaited trials	A1:B1B2-1	A1:B1B2-1	A1:B1B2-1	A1:B1B2-1
	A2:B1B2-1	A2:B1B2-1	A2:B1B2-1	A2:B1B2-1
	A1:C1C2-1	A1:C1C2-1	A1:C1C2-1	A1:C1C2-1
	A2:C1C2-1	A2:C1C2-1	A2:C1C2-1	A2:C1C2-1

Probe trials		
Reflexivity trial blocks[a]	Symmetry trial blocks	Transitivity trial blocks
A1:A1A2-1	B1:A1A2-1	B1:C1C2-1
A2:A1A2-1	B2:A1A2-1	B2:C1C2-1
B1:B1B2-1	C1:A1A2-1	C1:B1B2-1
B2:B1B2-1	C2:A1A2-1	C2:B1B2-1
C1:C1C2-1		
C2:C1C2-1		

Note: Underlining indicates reinforced choices. The number following hyphens reveals the number of times a trial type was presented in each block.

[a] On any trial block, four of these six trial types were presented.

Thus, subjects were required to show stable performances on baseline, reflexivity, symmetry, and transitivity concurrently across a minimum of 18 total trial blocks before conditions were changed.

Baseline contingency modifications. Contingencies for baseline conditional discriminations were then manipulated in one of three ways. Contingency changes were not signaled, and the arrangement and composition of trial blocks was unchanged from the previous phase.

For the AC reversal condition, contingencies for the AC conditional discrimination were completely reversed on baited AC trials. In the presence of Sample A1, selection of Stimulus C1 revealed a black token, whereas selection of Stimulus C2 revealed a white token. In the presence of Sample A2, selection of C2 revealed the black token and C1 the white token. In order to maintain reinforcement rates at 50%, one A1:C1C2 and one A2:C1C2 trial remained unbaited, as in the previous phase. Contingencies for AB relations were unchanged from the original baseline contingencies (see Table 1—AC reversal).

For the AC random condition, selection of C1 revealed a white token and C2 a black token on one trial with A1 as sample. Selecting C1 revealed a black token and selecting C2 revealed the white on another trial with A1 as sample. Exactly the same pattern was arranged when A2 was the sample. One additional AC trial with each sample type remained unbaited, and contingencies for AB relations were unchanged from the original baseline contingencies (see Table 1—AC random).

For the complete reversal condition, reinforcement contingencies were reversed from baseline conditions for baited AC and AB trials. In addition to the AC reversal described above, selection of Stimulus B1 in the presence of Sample A1 now revealed a black token and selection of B2 revealed a white one. Similarly, selection of B2 in the presence of A2 revealed a black token, and B1 revealed a white token. One trial with each of the baseline trial types remained unbaited (see Table 1—complete reversal).

All subjects except PP were exposed to more than one of these contingency manipulations. Conditions were changed only after stability criteria were met for all probe and baseline trial types. A new condition always went into

Table 2
Order, number of sessions, and number of trial blocks with probes for each condition.

Subject	Original discrim I	AC random	AC reversal	Complete reversal	Original discrim II
JM					
Order of conditions	1	3	2	—	—
Sessions/Trial blocks	4/23	4/33	6/44		
PJ					
Order of conditions	1	—	2	3	4
Sessions/Trial blocks	4/28		6/50	5/43	2/21
PP					
Order of conditions	1	2	—	—	—
Sessions/Trial blocks	5/34	9/75			
HH					
Order of conditions	1	2	3	—	4
Sessions/Trial blocks	5/47	9/98	6/64		2/21
DA					
Order of conditions	1	2	3	5	4
Sessions/Trial blocks	7/31	7/61	8/91	4/41	3/33

effect at the start of an experimental session. Table 2 shows, for each subject, the order and the number of sessions and trial blocks in each condition.

RESULTS

Figure 1 shows performances on baseline AC trials by trial block (i.e., six AC trials). Each data point represents the percentage of trials on which responding was consistent with the original conditional discrimination training contingencies. Data for performances on AB trials are presented in Table 3. Figure 1 and Table 3 reveal that the original conditional discriminations were readily acquired and were stable at or near 100% correct for all 5 subjects.

The top panels of Figure 1 show performances of Subjects JM and PJ, for whom AC reversal was the first conditional discrimination modification. For both subjects, responding adjusted to the new contingencies within the first few trial blocks, as reflected in near-zero "percent original" responding. Performances on the AB trials were unchanged (Table 3). The same pattern was observed for Subjects HH and DA when they were exposed to AC reversal.

As Figure 1 shows, response to the AC random condition was somewhat varied. When Subjects PP and HH were exposed to the random condition immediately after the original training and testing phase, their choices of C1 or C2, in keeping with the random contingency, varied unsystematically both within and across trial blocks. Subject DA showed the same pattern for two sessions after being switched from the original to the random condition, but then reverted completely to the conditional discrimination patterns shown during training. For Subject JM, the shift to random conditions from AC reversal also produced a brief return to original discrimination performances, but her terminal performance showed the same unsystematic alternation of C1 and C2 choices exhibited by Subjects PP and HH. Thus, 3 of the 4 subjects exposed to the AC random condition were similar in showing baseline performances that were consistent with the contingencies in effect. Performances on AB trials were maintained without disruption for all subjects in the random condition (Table 3).

Two subjects (PJ and DA) were also exposed to complete reversal conditions. Figure 1 shows that, for both subjects, AC trial performances were uniformly consistent with the new contingencies, and Table 3 shows that responding on AB trials was also completely reversed. Finally, 3 subjects (PJ, HH, and DA) were returned to the contingencies used during original baseline training at some point in the study, and all 3 showed a rapid return to original response patterns (see Figure 1).

Overall, performances on baseline trials showed clear sensitivity to the contingencies. When conditional relations were reinforced

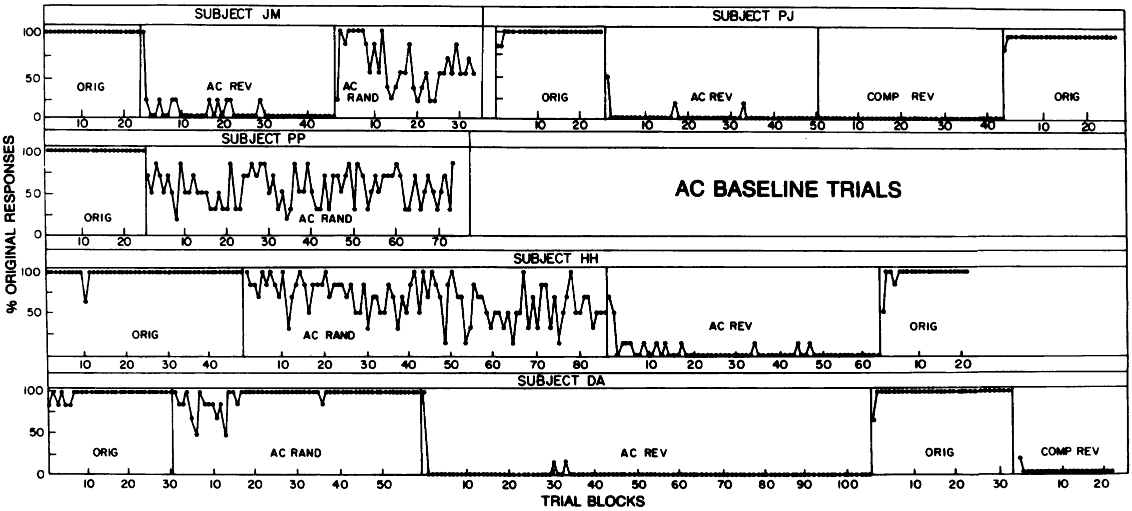

Fig. 1. Performances on the six AC baseline trials of every trial block. Consecutive trial blocks are represented on the horizontal axis. The vertical axis represents, for each block, the percentage of AC trials on which responses were consistent with the original training contingencies.

consistently, subjects quickly acquired the appropriate discriminations; when there was no reliably reinforced relation, performance varied accordingly. Contingency manipulations controlled changes in response patterns within two trial blocks in every case.

Data from all reflexivity probe trials are shown in Table 3. Although reflexivity was never reinforced explicitly, all 5 subjects showed evidence of this relation, and reflexive responding was unchanged throughout the experimental conditions.

Figure 2 shows CA symmetry probe performances by trial block (i.e., two CA probe trials). Each data point represents the percentage of trials on which responding was consistent with the equivalence classes established by original discrimination training conditions (i.e., A1B1C1 and A2B2C2). Comparable data for BA probe trials are given in Table 3.

Table 3

Percentage original responses across conditions (based on all relevant trials during the last two sessions for each condition).

Subject	Trial type	Original discrim I	AC random	AC reversal	Complete reversal	Original discrim II
JM	Baseline AB	100	100	100	—	—
	Reflexivity	100	100	100	—	—
	BA symmetry	100	100	100	—	—
PJ	Baseline AB	100	—	100	0	98
	Reflexivity	100	—	100	100	100
	BA symmetry	100	—	100	0	100
PP	Baseline AB	100	100	—	—	—
	Reflexivity	95	100	—	—	—
	BA symmetry	100	100	—	—	—
HH	Baseline AB	100	100	100	—	100
	Reflexivity	100	100	100	—	100
	BA symmetry	100	100	100	—	100
DA	Baseline AB	99	98	98	0	100
	Reflexivity	100	100	100	100	100
	BA symmetry	92	96	100	0	100

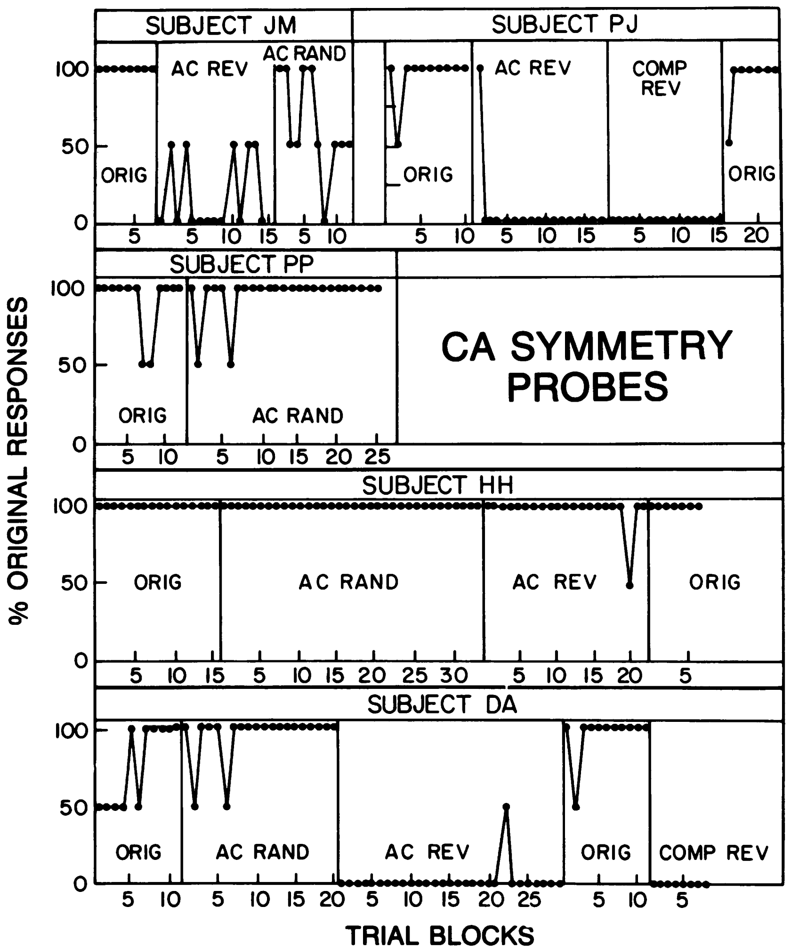

Fig. 2. Performances on the two CA symmetry probe trials of every symmetry trial block. Consecutive symmetry trial blocks are represented on the horizontal axis. The vertical axis represents, for each block, the percentage of CA trials on which responses are consistent with the equivalence classes established by the original training contingencies.

All 5 subjects showed stable symmetry responding following training with the original discrimination contingencies. Symmetry was evident immediately for Subjects JM, PP, and HH and emerged after two and six trial blocks, respectively, for Subjects PJ and DA.

In all but one case (Subject HH), the choice patterns exhibited on symmetry probe trials varied directly with reversals of the conditional discriminations on which they were based. In the AC reversal condition, Subjects PJ and DA consistently chose Comparison A2 given C1 as the sample, and A1 given C2 as the sample, whereas Subject JM showed the new selection pattern on at least one, if not both, of the CA probe trials in each block. In contrast, Subject HH maintained her original symmetry patterns on all but one probe, despite the new choice patterns she exhibited on AC baseline trials. BA symmetry performances were unchanged during this phase for any subject (see Table 3). Both subjects exposed to the complete reversal condition (PJ and DA) showed CA (Figure 2) and BA (Table 3) symmetry performances that were entirely consistent with their reversed baseline selections.

Symmetry performances were less likely to be influenced by the AC random condition. For 3 of the 4 subjects exposed to this condition (Subjects PP, HH, and DA), the original symmetry patterns were maintained on all but a total of four probes (see Figure 2). Thus, for Subject DA, the AC random condition affected neither baseline nor symmetry performances.

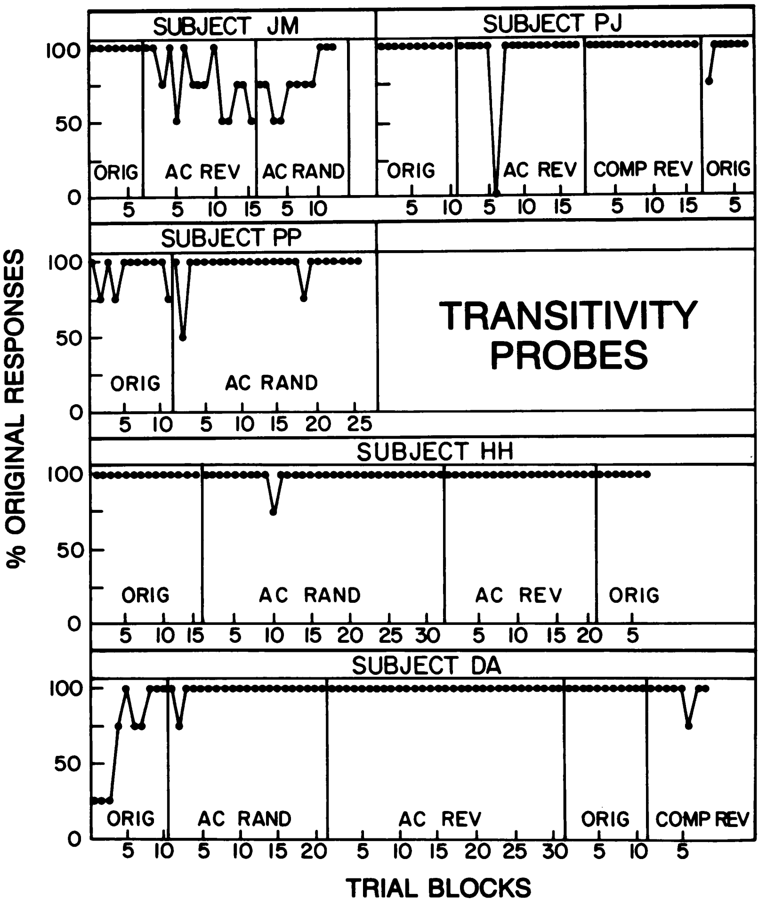

Fig. 3. Performances on the four transitivity probe trials of every transitivity trial block. Consecutive transitivity trial blocks are represented on the horizontal axis. The vertical axis represents, for each block, the percentage of transitivity trials on which responses were consistent with the equivalence classes established by the original training contingencies.

However, Subjects PP and HH showed unaltered symmetry performances, despite the changes observed in their baseline responding. Only Subject JM, who was exposed to the random condition after a reversal phase, showed an impact of the new conditions on symmetry performances. Her inconsistent pattern of choice on CA probe trials was in keeping with her unsystematic pattern of selections on AC baseline trials.

Figure 3 shows transitivity probe performances by trial block (i.e., four transitivity probe trials). Each data point represents the percentage of trials on which responding was consistent with the equivalence classes established by original discrimination training conditions (i.e., A1B1C1 and A2B2C2). As Figure 3 shows, transitivity was evident in the first probe-trial block following training for Subjects JM, PJ, and HH and emerged after four and seven trial blocks for Subjects PP and DA, respectively.

Once established, transitivity performances were strikingly insensitive to modification of the conditional discriminations on which they were based. When exposed to the AC random condition immediately following training, 3 subjects (PP, HH, and DA) had a total of only five probe trials in which responding was inconsistent with the original equivalence pattern. A 4th subject (Subject JM) actually returned to original responding in the random condition. In general, the AC reversal condition had a similar lack of effect on transitivity probes. Subjects PJ, HH, and DA all responded as if original transitive relations were intact throughout the condition. Only Subject JM showed any change during AC reversal, and even in this case no systematic pattern indicative of class modification was revealed. Original response patterns were shown on at least 50% of the probe trials in any trial block. During the complete reversal condition, Subjects PJ and DA maintained their original transitive response patterns on all but a single probe trial; however, interpretation of these performances is problematic. Although consistent with original conditions, these performances were also consistent with conditional discriminations produced by the complete reversal conditions (i.e., B1C1 and B2C2 remained classmates even if classes were modified by complete reversal conditions).

DISCUSSION

In keeping with the growing literature on stimulus equivalence (e.g., Sidman, 1971; Sidman et al., 1985; Sidman & Tailby, 1982; Spradlin, Cotter, & Baxley, 1973), results of the present study revealed the emergence of two three-member equivalence classes, defined by the properties of reflexivity, symmetry, and transitivity, following the explicit reinforcement of two simple conditional discriminations. In addition, the present results revealed that those trained conditional discriminations were extremely sensitive to manipulations in their reinforcement contingencies. For all 5 subjects, baseline performances almost always conformed rapidly to the new contingencies when reinforcement conditions were changed (the exception being Subject DA in the AC random condition).

Notable in the present results, however, was that contingency manipulations had an inconsistent influence on stimulus classes, at least as defined by probe performances, even while they clearly controlled the conditional discriminations that gave rise to the equivalence relations. For example, the transitive performances that had initially helped prove the existence of two distinct three-member equivalence classes remained unchanged by any of the contingency manipulations. Performances on symmetry probe trials, however, were likely to vary when discrimination contingencies were reversed. Indeed, for 3 of 4 subjects (JM, PJ, and DA), new baseline discriminations immediately resulted in new symmetry response patterns. Thus, symmetry performances became inconsistent with the equivalence classes that were originally demonstrated. More important, these symmetry performances were inconsistent with the response patterns simultaneously exhibited on transitivity probes.

These results seem surprising given current theoretical analyses of equivalence classes. For example, modification of the initial conditional discriminations might have been expected to result in the formation of new equivalence classes whose members differed from those of the original classes. Given AC reversal, new classes composed of A1B1C2 and A2B2C1 could have developed; similarly, given complete reversal conditions, classes composed of A1B2C2 and A2B1C1 could have emerged. It is evident that these classes would have emerged if the reversed relations had been the first ones taught. There was, however, little indication that new equivalence classes formed. As noted earlier, however, definitive evaluation of the emergence of new classes after complete reversal was impossible. Presence of either the original classes (i.e., A1B1C1, A2B2C2) or new classes (i.e., A1B2C2, A2B1C1) would result in identical performances on BC or CB transitivity probes. Although symmetry performances frequently reflected the reversed contingencies, transitive responding did not vary from the pattern shown under original training conditions.

An alternative theoretical account might hold that the original stimulus classes should persist, even when discriminations were reversed, due to the multiple ways in which stimulus class members can be related to each other. Thus, even if a particular relation were weakened, it might reemerge based on remaining class relations. Given that the present study involved small three-member classes, the opportunity for multiple determination is rather limited. However, support for such an analysis may be derived from a study by Saunders, Saunders, Kirby, and Spradlin (1988), who reported that when the conditional selections that had merged classes were reversed, the original merger patterns were maintained, as measured by transitivity probes. The conclusion of Saunders et al. emphasized the impressive durability of equivalence relations; their findings are similar to those of the present study in that transitive performances remained consistent with originally established equivalence classes. However, the Saunders et al. study did not test for symmetry of the reversed relations, and their account does not seem to address the inconsistency between symmetry and transitivity probe performances seen in the present study. Even in the case of Subject HH, who did show consistent performances across probe types, the appropriateness of inferring persistent equivalence when probe patterns are inconsistent with conditional discriminations may be questioned. When inconsistencies appear across probe performances, as they did for the other 4 subjects, even more fundamental questions are raised about the integrity of the original equivalence classes.

Another possible analysis suggests that the present experimental manipulations would result in the collapse of equivalence classes. The inconsistent reinforcement patterns of the AC random condition might disrupt the baseline units, thus removing the prerequisites for equivalence. Alternatively, a history of reinforcement for choosing C1 in the presence of both A1 and A2 might establish members common to the two classes, causing them to collapse into a single six-member class. Following collapse, each trial would functionally require a choice between two members of the same class, and an absence of consistent choice patterns on probe trials might be expected. This was definitely not the pattern observed in the present study. However, given a history of reinforced conditional responding, it is possible that subjects would continue to respond conditionally even following class collapse. Saunders, Saunders, Kirby, and Spradlin (1988) reported consistent conditional responding by individual subjects in the absence of explicit contingencies. Emergence of arbitrary conditional responding, however, would not predict the consistencies in direction of conditionality shown across subjects in the present study (i.e., all 4 subjects in the AC reversal condition maintained original conditionality patterns on transitivity probes). Even if the transitivity performances could be accounted for (e.g., by assuming that well-practiced patterns would be more likely to persist), it is not clear why consistent symmetry patterns in accord with the reversed contingencies (see Subjects PJ, DA, and JM) would occur. Also striking is the close correspondence between successive manipulations of baseline contingencies and the direction of conditionality shown on CA symmetry probes (particularly Subjects PJ and DA). These data imply a degree of control inconsistent with arbitrary conditionality.

Other current conceptions of stimulus classes have noted that relations between stimuli other than equivalence can be trained (Hayes, in press). With respect to the present data it might then be argued that after learning equivalence relations between A and C stimuli (e.g., A1 equals C1), a contingency reversal may represent a relation of opposition (e.g., A1 does not equal C2). From this perspective, the relations learned during reversal conditions might not be expected to alter the original equivalence classes, thus leaving probe performances unchanged. This explanation necessitates the assumption that all subjects learned a different type of stimulus relation with reversed discriminations than they did with the original discriminations, despite the absence of explicit contingencies for doing so. Nonetheless an "oppositional relation" account might be entertained given the otherwise perplexing maintenance of original transitive response patterns observed after reversal in the present study. However, the emergence of oppositional relations would not explain the changes in performances on symmetry probes observed in 3 of 4 subjects tested under AC reversal conditions. Thus, the observed differences between performances on symmetry and transitivity probes pose the same problems for the oppositional relation account as they did for the one-class hypothesis and other more traditional equivalence formulations.

Another approach that offers the possibility of bringing the present data in line with more traditional accounts emphasizes contextual control (e.g., Bush et al., 1989; Sidman, 1986; Wulfert & Hayes, 1988). For example, this position could assert that new equivalence classes had formed following the reversed conditional discriminations. Demonstration of these new relations (e.g., reversed CA symmetry patterns during AC reversal) versus their original counterparts (e.g., original transitivity patterns during AC reversal), however, would depend on the presence of contextual cues that occasioned either old or new response patterns. A contextual approach may account for the present data; however, it becomes somewhat unsatisfactory upon complete examination.

First, there is no clear reason for contextual control to emerge. Explicit contingencies were never arranged to bring alternative class memberships (e.g., the old equivalence relations versus the modified patterns) under conditional control of another stimulus. Second, the contextual approach does not explain why the patterns of conditionality shown were generally consistent across subjects (cf. Subject HH on symmetry trials in AC reversal). Given the absence of explicit contingencies, the direction of conditionality should be free to vary. Thus, although possible, the probability of obtaining the consistency in direction of conditional responding shown by these subjects due to chance seems rather small.

Finally, a contextual control explanation would need to specify the nature of the contextual stimuli that acquired control. Given the present results, the stimulus complex controlling new equivalence relations would have to include probe trials composed of sample and comparison stimuli that had been presented together on baseline trials involving reversed contingencies, whereas probe trials composed of sample and comparison stimuli that had not been presented together on a reversed baseline trial should control old relations. In sum, a contextual control account requires that control by a fairly complex combination of stimulus elements emerged in the absence of explicit reinforcement and coincidentally exerted complete and immediate control in directions that were consistent across multiple conditions and several subjects. Although feasible, the account is also somewhat cumbersome and unparsimonious as applied to the present data.

In conclusion, current formulations of equivalence class formation and maintenance provide no simple account for the dissociation between symmetry and transitivity performances obtained in the present study. The key problem is that manipulation of the relations that theoretically gave rise to stimulus classes caused alteration in some equivalence properties (i.e., prerequisite conditional discriminations and, in some cases, symmetry) while others (i.e., transitivity) remained unchanged. Although some studies have found changes in probe performances after reversals of baseline contingencies using somewhat different procedures (Dube, McIlvane, Maguire, Mackay, & Stoddard, 1989; Spradlin et al., 1973), the present data are troublesome because they seem to be inconsistent with the functional substitutability of stimuli that defines equivalence classes. In the present study, manipulations have been identified that appear to affect some properties of the equivalence class without affecting others. Alternatively, these findings may be viewed as suggesting that variables other than equivalence classes can influence probe performances. More research on the determinants of probe performances seems needed, but for the present, caution is indicated in making inferences from such performances.

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APPENDIX

Instructions

Please read these instructions along with me as I read them out loud.

This is an experiment in learning—it is not a psychological test. We are investigating certain aspects of the learning process which are common to all people.

More specifically, we are interested in finding out how much money you will be able to make on a learning task. In other words, your job in this experiment will be to make as much money as you can. The way in which you can make money works like this:

On each trial of this experiment you will be shown a group of three (3) different objects. The object in the center position will always be the example stimulus. The other two objects on the tray are your choices. After you have looked at the example stimulus in the center, you should make a choice by picking up *one* of the choice objects on either side. (Please make your choice promptly.)

Sometimes you will find a bean underneath the object you have chosen. Each white bean you find is worth *+1 penny* toward your total earnings. However, a black bean underneath the chosen object will *subtract 1 penny* from your earnings. When you find a bean, please remove it and deposit it in the appropriate cup in front of you. Also, please note that *on some trials there will be no bean under either choice.*

For each trial, please return the object to its original position after you have made your choice. I will start the next trial at that time.

If you have any questions, please ask them at this time. I will not be able to answer any questions or make any comments once we've begun.

The session today will be divided into blocks of trials. We'll be taking a short break between each trial block so that you can relax and I can get organized.

Again, remember that your job is to make as much money as you can.